**NCT7509Y**

**NCT7509W**

**Nuvoton Thermal Sensor IC
with Fan Control**

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## 1. GENERAL DESCRIPTION

The NCT7509 is a Nuvoton Hardware Monitor IC, contains 1 remote and 1 on-die temperature sensor and 1 fan controller with SMBus™ interface. The remote sensor is diode-connected transistor, such as 2N3904 or the thermal diode integrated in Computer Processor Units (CPU) and Graphics Processor Units (GPU). The NCT7509 also supports offset adjust register to correct the errors that casued by different thermal diodes.

The fan controller in NCT7509 support PWM (pulse width modulation) fan output modes for Nuvoton SMART FAN™ control - "Thermal Cruise™" mode and "SMART FAN™ IV" mode. In the "Thermal Cruise™" mode, temperatures of CPU/GPU and the system can be maintained within specific programmable ranges under the hardware control. SMART FAN™ IV provides 8 sets of temperatures setting points to program 6 slopes linear fan speed vs. temperature transfer function. NCT7509 also supports close-loop fan controller based on RPM. The NCT7509 provides an easy to implement cooling and quiet solution with maximum safety and flexibility.

The NCT7509 supports 2 wire alert signals which ALERT# is for processor event notification and T_CRIT is for thermal shutdown.

## 2. FEATURES

### 2.1 Fan Speed Monitoring and Control

- Support 256 steps PWM modes fan speed control
- Thermal Cruise™ and SMART FAN™IV to control the fan speed
- Enhanced Smart Fan algorithm, SMART FAN™ IV, supports multi-tracking of fan control vs. temperature and registers for each fan control output.
- Closed-loop fan controller via RPM setting
- Manual Mode for specific application

### 2.2 Temperature Measurement

- Measure the temperature with high accuracy
- One local on-die thermal sensor
- One remote temperature sensor with current mode

### 2.3 Event Notification

- Supports 2 alert outputs : ALERT# and T_CRIT#
- Event notification via ALERT# signal for over temperature and fan error
- ALERT# output supports SMBus™ 2.0 ARA function
- T_CRIT# point supports Hardware Power-on setting

### 2.4 General

- $I^2C$® Compatible System Management bus (SMBus™)
- 3.3V±5% VDD operation
- 10-pin MSOP and DFN Green Package (Halogen-free)

## 3. KEY SPECIFICATIONS

| PARAMETER | RATING |
|---|---|
| Local temperature range and accuracy | -40°C to +125°C |
| | Typ. ± 2°C (20°C~40°C) |
| | Max. ± 3°C (-40°C~125°C)*1 |
| Remote temperature range and accuracy | -40°C to +127°C |
| | Typ. ± 1°C (25°C ~70°C) |
| | Typ. ± 2°C (-40°C ~127°C) |
| | Max. ± 3°C (-40°C~127°C)*2 |
| Supply voltage | 3.3V ± 5% |
| Operating supply current | 3 mA typ. |
| ADC resolution include sign bit | 10 Bits |

*1 Guaranteed by design from -40~125 degreeC, 100% tested at 85 degreeC.

*2 Guaranteed by design from -40~127 degreeC, 100% tested at 85 degreeC.

## 4. PIN CONFIGURATION
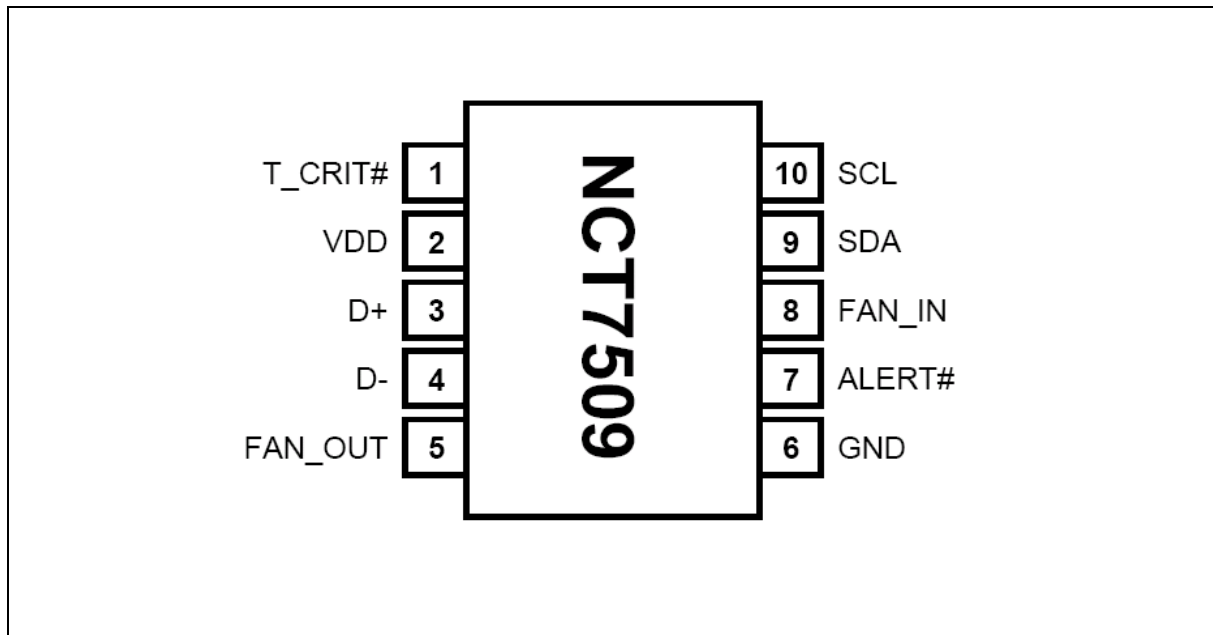
## 5. PIN DESCRIPTION

### 5.1 PIN TYPE DISCRIPTION

| PIN TYPE | PIN ATTRIBUTE |
|---|---|
| $OD_{12}$ | Open-drain output pin with 12 mA sink capability |
| $IN_{ts}$ | TTL level input pin and schmitt trigger |
| AIN | Input pin (Analog) |
| P | Power or Ground Pin |

### 5.2 PIN DISCRIPTION

| PIN NO. | PIN NAME | I/O | FUNCTION |
|---|---|---|---|
| 1 | T_CRIT# | $OD_{12}$ | T_CRIT alarm output, for interrupt or shutdown control |
| 2 | VDD | P | DC Power supply, Voltage input 3.3V±5% |
| 3 | D+ | AIN | Connect to Thermal Diode Anode |
| 4 | D- | AIN | Connect to Thermal Diode Cathode |
| 5 | FAN_OUT | $OD_{12}$ | Fan speed control PWM output |
| 6 | GND | P | Power supply ground |
| 7 | ALERT# | $OD_{12}$ | Alarm output, for interrupt control |
| 8 | FAN_IN | $IN_{ts}$ | Fan tachometer input |
| 9 | SDA | $IN_{ts}$/ $OD_{12}$ | SMBus$^{TM}$ bi-directional data |
| 10 | SCL | $IN_{ts}$ | SMBus$^{TM}$ Clock |

## 6. FUNCTION DESCRIPTION

### 6.1 General Description

NCT7509 is SMBus™ interface device to provides on-die temperature sensor and 1 set of thermal inputs for CPU/GPU thermal diode sensor, 2 wire alert signals which ALERT# is for processor event notification and T_CRIT# is for thermal shutdown,1set fan speed input and output which support PWM(Pulse Width Modulation) fan control.

### 6.2 Access Interface

NCT7509 provides SMBus™ to access the internal register. It supports SMBus™ byte write and byte read protocols.

### 6.2.1 Data write to the internal register
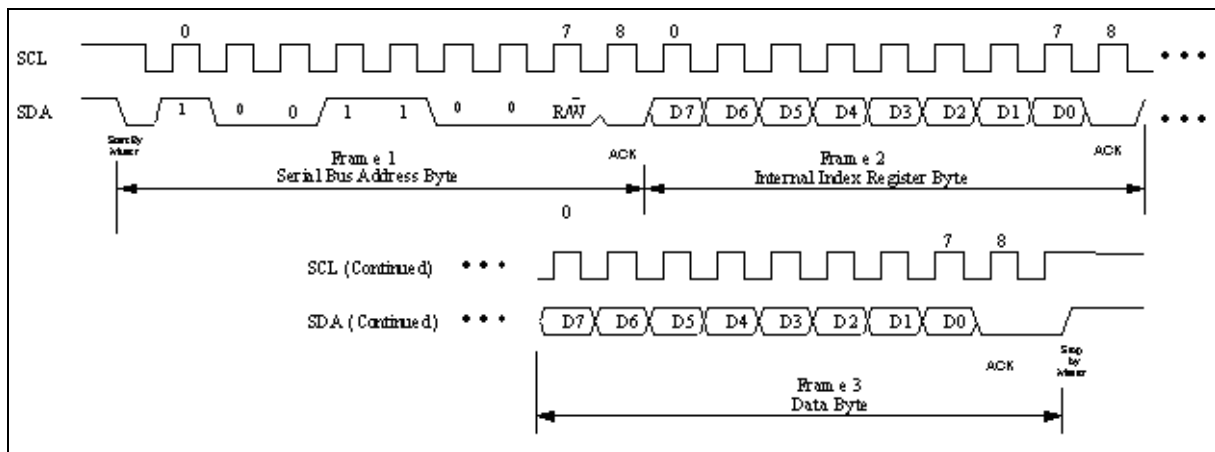


### 6.2.2 Data read from the internal register
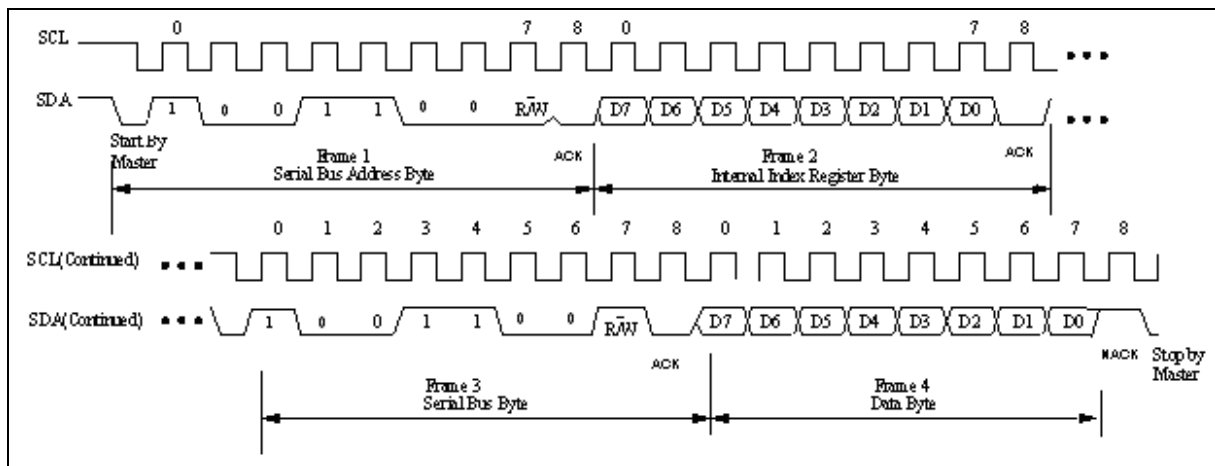
## 6.3 Address Setting

NCT7509 I2C/SMBus™ address is 1001100xb (x is R/W bit).

## 6.4 Temperature Measurement Data Format

### 6.4.1 The local temperature (on-die) data with 8-bit 2`s complement format.

| TEMPERATURE | 8-BIT DIGITAL OUTPUT |
|---|---|
| +127°C | 0111,1111 |
| +25°C | 0001,1001 |
| +2°C | 0000,0010 |
| +1°C | 0000,0001 |
| +0°C | 0000,0000 |
| - 1°C | 1111,1111 |
| - 2°C | 1111,1110 |
| - 25°C | 1110,0111 |
| - 128°C | 1000,0000 |

### 6.4.2 The remote temperature data with 11-bit 2`s complement format.

| TEMPERATURE | 8-BIT DIGITAL OUTPUT HIGH BYTE | 3-BIT DIGITAL OUTPUT LOW BYTE |
|---|---|---|
| +127.875°C | 0111,1111 | 111X,XXXX |
| +25.750°C | 0001,1001 | 110X,XXXX |
| +2.250°C | 0000,0010 | 010X,XXXX |
| +1.125°C | 0000,0001 | 001X,XXXX |
| +0.000°C | 0000,0000 | 000X,XXXX |
| - 1.125°C | 1111,1110 | 111X,XXXX |
| - 2.250°C | 1111,1101 | 110X,XXXX |
| - 25.750°C | 1110,0110 | 010X,XXXX |
| - 127.875°C | 1000,0000 | 001X,XXXX |

## 6.5 ALERT# Output

The NCT7509 ALERT# pin is an active-low open-drain output pin which is triggered when measured temperature exceeds the limitation defined in the limit registers. There are three types of ALERT#

output mode: the ALERT# output comparator mode, the ALERT# output interrupt mode, and the ALERT# output SMBus™ ALERT# mode.

### 6.5.1 ALERT# Output Comparator Mode

Figure 1 shows the mechanism of the ALERT# output comparator mode. In this mode, the ALERT# pin will be alerted if the monitored temperature is out-of-limit and the ALERT# pin keeps low until the temperature goes back to the target range.
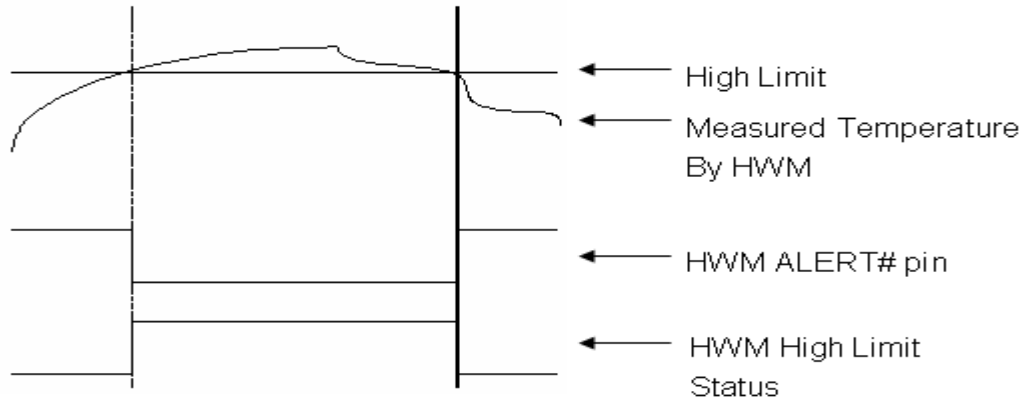


Figure 1

### 6.5.2 ALERT# Output Interrupt Mode

Figure 2 shows the mechanism of the ALERT# output interrupt mode. In this mode, the NCT7509 will set the ALERT mask bit of Configuration Register during a read of the Status Register if any flag in Status Register, except the ADC_Busy flag and Remote Diode Open flag, is set. This prevents further ALERT# triggering until the master has reset the ALERT mask bit (write 0 to Alert_MSK), at the end of the interrupt service routine. The Status Register flags are cleared only upon a read Status Register command from the master and will be re-alerted at the end of the next temperature conversion if the measured temperature still falls outside of the allowed range.
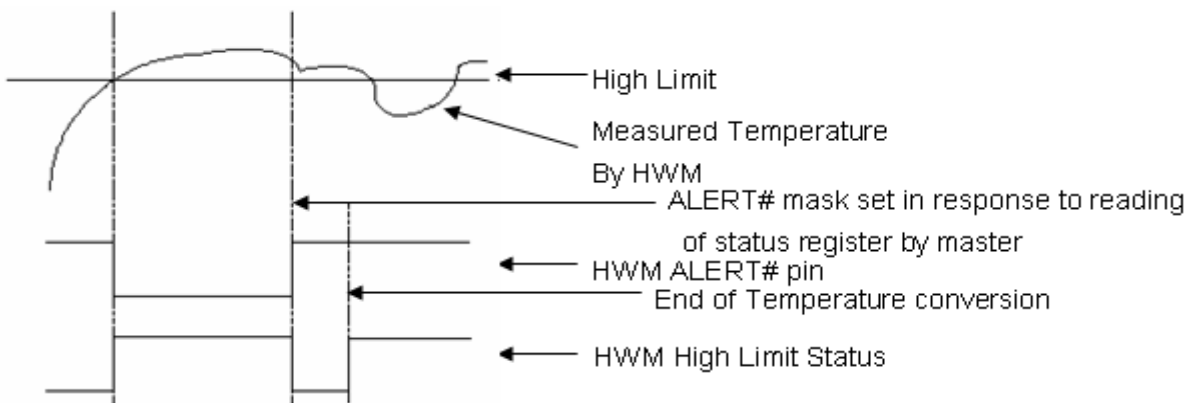


Figure 2

### 6.5.3    ALERT# Output SMBus<sup>TM</sup> alert Mode

Figure 3 shows the mechanism of the ALERT# output SMBus<sup>TM</sup> alert mode. In this mode, the ALERT# output of the NCT7509 is connected to the SMBus<sup>TM</sup> alert line which has more than one device connected to it. Through such and implementation, SMBus<sup>TM</sup> alert mode can assist the master in resolving which salve generates an interrupt. When the measured temperature falls outside of the allowed range, the ALERT# pin will be pulled low and the corresponding alert flags in Status Register will be set to 1. The ALERT mask bit will just be set if there is a read command for Status Register or when SMBus<sup>TM</sup> ALERT Response Address (ARA) occurs from master (Alert Response Address is 0001100x). Meanwhile, the NCT7509 will generate and return its own address to the master. If the temperature never falls outside of the allowed range, the latched ALERT# pin can release by the reset ALERT mask bit and the latched corresponding alert flags in Status Register can release by reading command for Status Register.
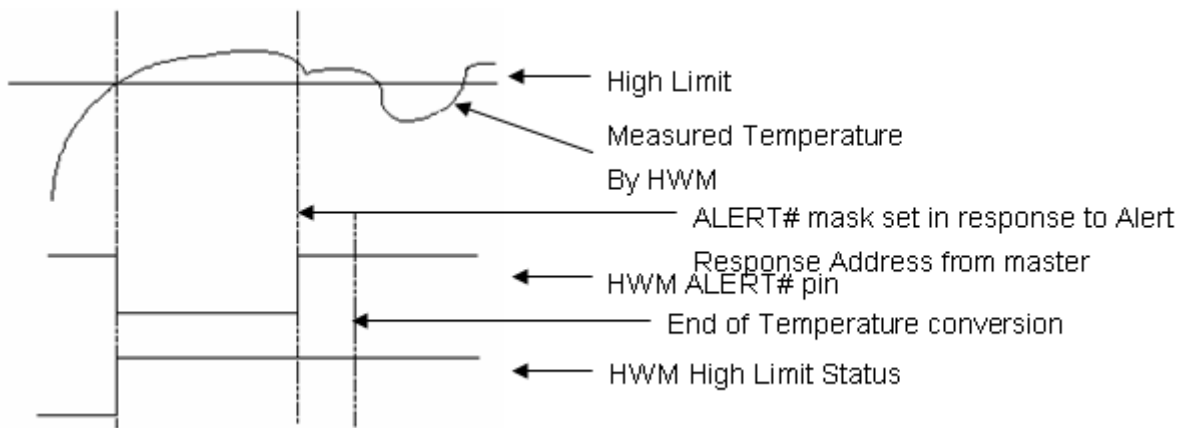


Figure 3

### 6.6    T_CRIT# Output

T_CRIT# output pulls low when the measured temperature exceeds the critical temperature setting. Once the T_CRIT# output pulls low, it will not be set high until the measured temperature is lower than "T_CRIT – TH", where TH is Temperature Hysteresis. Status Register will not be reset until it is read and the temperature conversion falls below the T_CRIT set point, the ALERT-MSK bit of Configuration Register will be set after Status Register read. Figure 4 shows this mechanism.
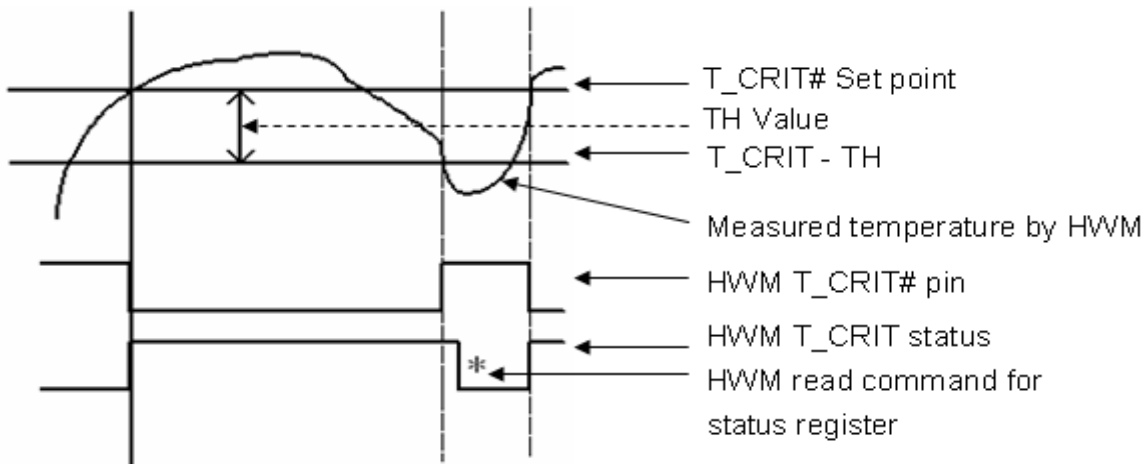


Figure 4

## 6.7 FAN_IN Count Calculation

The FAN_IN tachometer high byte and low byte are combined to 12-bitCountValue. Real RPM (Rotate per Minute) calculation should follow the formula:

$$FanSpeed(RPM) = \frac{1.35 \times 10^6}{(12 - bitCountValue) \times (FanPoles/4)}$$

In this formula, FanPoles stands for the number of NS pole pairs inside the fan. Normally an N-S-N-S Fan (FanPoles=4) generates 2 pulses after completing one rotation.

## 6.8 FAN_OUT Duty Cycle Calculation

The NCT7509 provides 1 set of PWM for fan speed control. The duty cycle of PWM can be programmed by an 8-bit register. The expression of duty cycle can be represented as follow formula:

$$Duty-cycle(\%) = \frac{\text{Programmed 8-bit Register Value}}{255} \times 100\%$$

## 6.9 SMART FAN™ IV Control Parameters

In SMART FAN™ IV Mode, there are some Fan control parameters as below descriptions:

### 6.9.1 Step Up Time / Step Down Time

SMART FAN™ IV is designed for the smooth operation of the fan. The Up Time / Down Time register defines the time interval between successive duty increases or decreases. If this value is set too small, the fan will not have enough time to speed up after tuning the duty and sometimes may result in unstable fan speed. On the other hand, if Up Time / Down Time is set too large, the fan may not work fast enough to dissipate the heat. This register should never be set to 0, otherwise, the fan duty will be abnormal.

### 6.9.2 Fan Output Start-up Value

From still to rotate, the fan usually needs a higher fan output value to generate enough torque to conquer the restriction force. Thus the Fan Output Start-up Value is used to turn on the fan with the specified output value.

### 6.9.3 Fan Output Nonstop Value

It takes some time to bring a fan from still to working state. Therefore, Nonstop value are designed with a minimum fan output to keep the fan working when the system does not require the fan to help reduce heat but still want to keep the fast response time to speed up the fan.

## 6.9.4   Fan Output Stop Time

A time interval is specified to turn off the fan if SMART FAN$^{TM}$ IV continuously requests to slow down the fan which has already reached the Stop time.
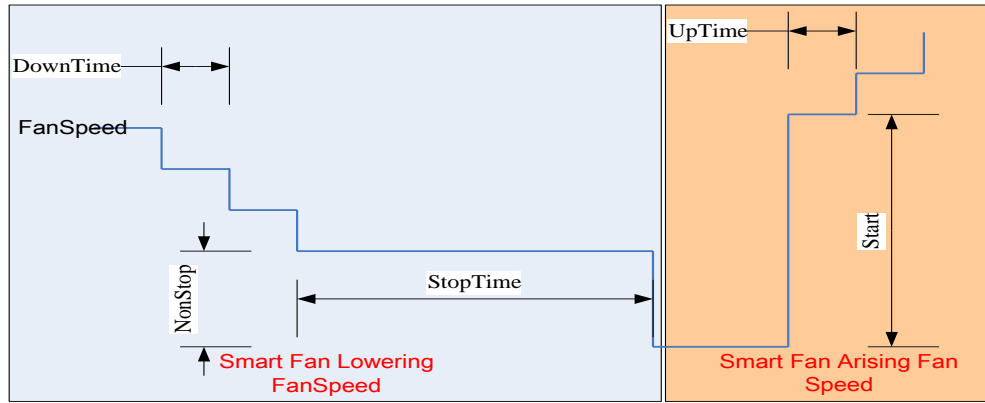


**Smart Fan Control Parameters Figure**

## 6.10  Speed Cruise Mode

Fan Speed Cruise mode keeps the fan speed in a specified range. This range is defined by a fan speed count and an interval (e.g., 160 ± 10). As long as the fan speed count is in the specified range, fan output remains the same. If the fan speed count is higher than the high end (e.g., 170), fan output increases to make the count lower. If the fan speed count is lower than the low end (e.g., 150), fan output decreases to make the count higher. One example is illustrated in this figure.
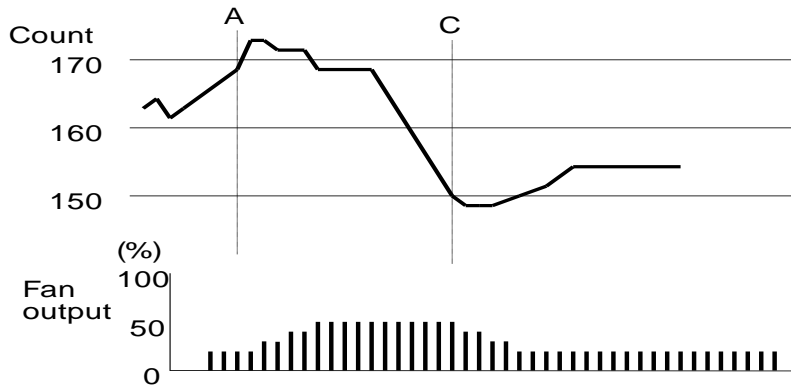


**Mechanism of Fan Speed Cruise$^{TM}$ Mode**

## 6.11 Thermal Cruise Mode

Thermal Cruise mode is an algorithm to control the fan speed to keep the temperature source around the Target Temperature of Temperature Inputs. If the temperature source detects temperatures higher or lower than the target temperatures with Hysteresis of Temperature, Smart Fan Control will take actions to speed up or slow down the fan to keep the temperature within the tolerance range.

Thermal Cruise mode controls the fan speed to keep the temperature in a specified range. This range is defined by a temperature and the interval (e.g., 55 °C ± 3 °C). As long as the current temperature remains below the low end of this range (i.e., 52 °C), the fan is off. Once the temperature exceeds the low end, the fan turns on at a start up speed defined (e.g., 20% output). Thermal Cruise mode then controls the fan output according to the current temperature. Three conditions may occur:

(1) If the temperature still exceeds the high end, fan output increases slowly. If the fan is operating at full speed but the temperature still exceeds the high end, a warning message is issued to protect the system.

(2) If the temperature falls below the high end (e.g., 58°C) but remains above the low end (e.g., 52 °C), fan output remains the same.

(3) If the temperature falls below the low end (e.g., 52 °C), fan output decreases slowly to zero or to a specified "Nonstop value". This nonstop value is specified in **Address 5A$_{HEX}$.** The fan remains at the nonstop value for the period of time defined in **Address 5B$_{HEX}$.**

In general, Thermal Cruise mode means
- if the current temperature is higher than the high end, increase the fan speed;
- if the current temperature is lower than the low end, decrease the fan speed;
- otherwise, keep the fan speed the same.

The following figures illustrate two examples of Thermal Cruise mode.
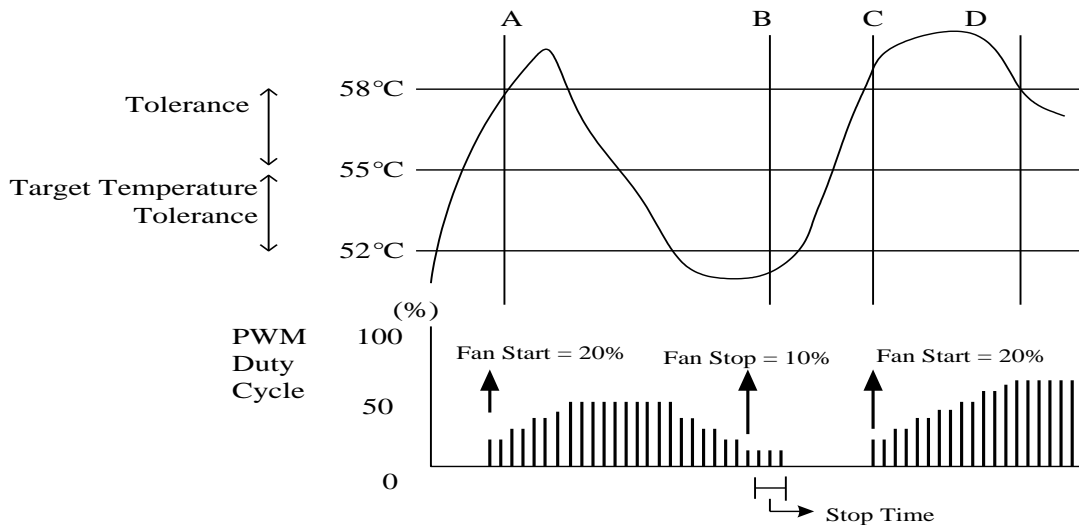


**Mechanism of Thermal Cruise$^{TM}$ Mode (PWM Duty Cycle)**

## 6.12 SMART FAN<sup>TM</sup> IV & Close Loop Fan Control Mode

SMART FAN<sup>TM</sup> IV and Close Loop Fan Control Mode offer 6 slopes to control the fan speed.

The 6 slopes can be obtained by setting FanDuty/RPM1~FanDuty/RPM7 and T1~T7 through the registers. When the temperature rises, FAN Output will calculate the target FanDuty/RPM based on the current slope. For example, assuming Tx is the current temperature and FanDuty/RPMy is the target, then the slope:

$$X4 = \frac{(FanDuty5/RPM\,5) - (FanDuty4/RPM\,4)}{(T5 - T4)}$$

Fan Output:

$$T\arg et\;FanDuty\;or\;RPM = (FanDuty4\;or\;RPM\,4) + (Tx - T4) \cdot X4$$
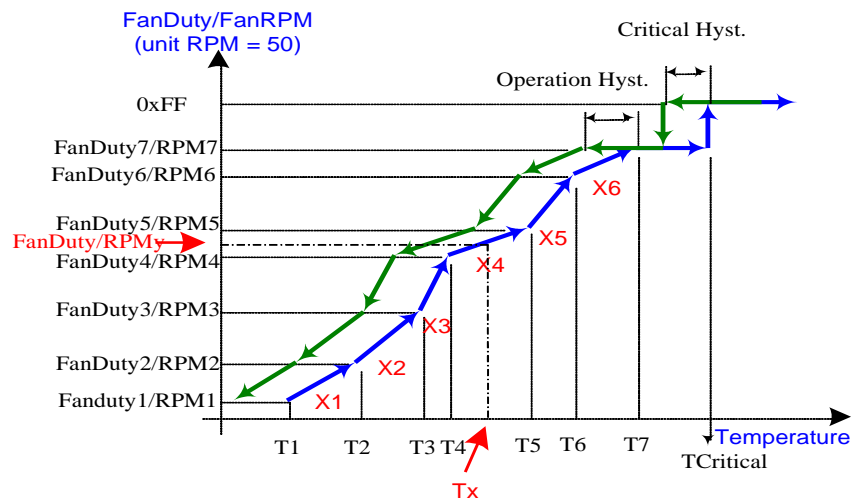


**SMART FAN<sup>TM</sup> IV & Close Loop Fan Control Mechanism**

In addition, SMART FAN<sup>TM</sup> IV & Close Loop Fan Control can also set up Critical Temperature and Hysteresis. If the current temperature exceeds Critical Temperature, external fan will be forced by maximum FanDuty to meet the largest target FanDuty or RPM, Which is 0xFF. The target FanDuty & RPM value will be determined in accordance to the slope only when the temperature falls below (TCritical – Criticl Hyst.)

NCT7509 provide 2 temperature source selects to map the fan, the algorithm will make a decision to control the fan as below figure:
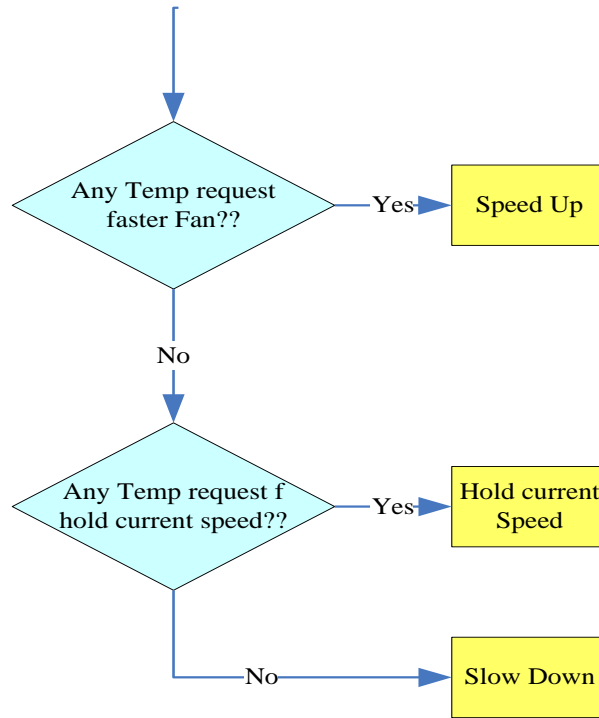
## 6.13 Dynamic Fast Tracking Feature

In the SMART FAN$^{TM}$ IV & Close Loop Control Mode, in order to have a faster Fan Duty update response to external temperature variation, NCT7509 involves a Dynamic Fast Tracking mode. That how fast could be reached is depended on user's configuration and how rapid temperature variation.

In addition to independent temperature control method, which means that one external fan would be controlled by only one temperature source, NCT7509 also support combined temperature control method. User could conjugate CPU & System temperature with CPU fan to obtain a better thermal management on the system level through this feature.

Per appropriate configuration, fan control response time could come out following behavior.
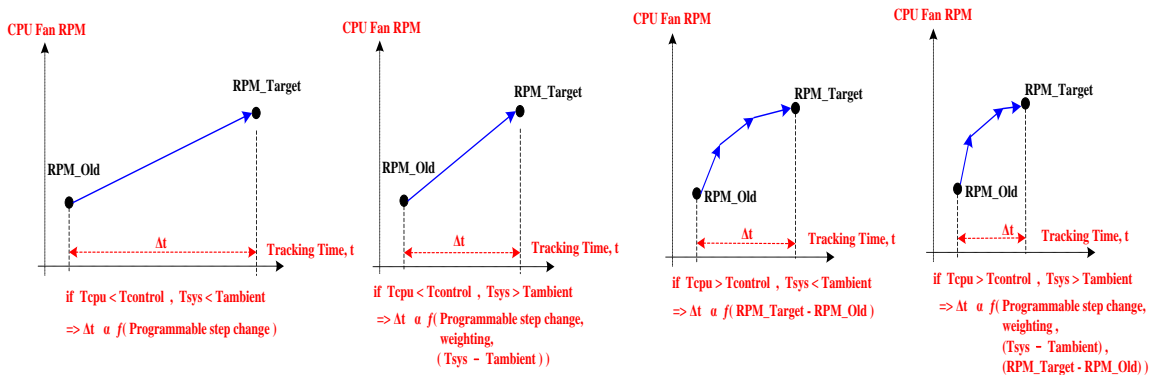


In this demonstration, CPU & System temperature will link to CPU fan response.

## 7. REGISTER SUMMARY

### 7.1 Register Map

| Idx | Register Name | Attr | Dft | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | LDT Readout | RO | 00 | MNTREG_LT[7:0] | | | | | | | |
| 1 | RT1 Temp MSB | RO | 00 | MNTREG_RT1[10:3] | | | | | | | |
| 2 | Alert Status | RO | 00 | ADC_Busy | STS_LTHA | Reserved | STS_RT1HA | STS_RT1LA | STS_RT1O | STS_RT1C | STS_TACH |
| 3 | Configuration [R] | RW | 15 | ALERT_MSK | STOP_Mnt | DIS_FANOUT | EN_FANIN | Reserved | EN_RT1 | EN_WTC | EN_FaultQueue |
| 4 | Conversion Rate [R] | RW | 08 | Reserved | | | | ConvRate[3:0] | | | |
| 5 | LT Alert Temp [R] | RW | 46 | LT_HAT[7:0] | | | | | | | |
| 6 | Reserved | | | Reserved | | | | | | | |
| 7 | RT1 High Alert Temp MSB [R] | RW | 46 | RT1_HAT[10:3] | | | | | | | |
| 8 | RT1 Low Alert Temp MSB [R] | RW | D8 | RT1_LAT[10:3] | | | | | | | |
| 9 | Configuration [W] | RW | 15 | ALERT_MSK | STOP_Mnt | DIS_FANOUT | EN_FANIN | Reserved | EN_RT1 | EN_WTC | EN_FaultQueue |
| A | Conversion Rate [W] | RW | 08 | Reserved | | | | ConvRate[3:0] | | | |
| B | LT Alert Temp [W] | RW | 46 | LT_HAT[7:0] | | | | | | | |
| C | Reserved | | | Reserved | | | | | | | |
| D | RT1 High Alert Temp MSB [W] | RW | 46 | RT1_HAT[10:3] | | | | | | | |
| E | RT1 Low Alert Temp MSB [W] | RW | D8 | RT1_LAT[10:3] | | | | | | | |
| F | One Shot Conversion | WO | FF | | | | | | | | |
| 10 | RT1 Temp LSB | RO | 00 | MNTREG_RT1[2:0] | | | Reserved | | | | |
| 11 | RT1 Offset Temp MSB | RW | 00 | OFFSET_RT1[10:3] | | | | | | | |
| 12 | RT1 Offset Temp LSB | RW | 00 | OFFSET_RT1[2:0] | | | Reserved | | | | |
| 13 | RT1 High Alert Temp LSB | RW | 00 | RT1_HAT[2:0] | | | Reserved | | | | |
| 14 | RT1 Low Alert Temp LSB | RW | 00 | RT1_LAT[2:0] | | | Reserved | | | | |
| 16 | Alert Mask | RW | 06 | MSK_LTH | Reserved | MSK_RT1H | MSK_RT1L | Reserved | | MSK_RT1C | MSK_TACH |
| 19 | RT1 Critical Temp | RW | -- | RT1_CT[7:0] | | | | | | | |
| 20 | Reserved | | | Reserved | | | | | | | |
| 21 | Critical Temp Hysteresis | RW | 0A | Reserved | | | | CTH[4:0] | | | |
| 2D | Customer Data Log Register 1 | RW | 00 | CustomerLogReg1[7:0] | | | | | | | |
| 2E | Customer Data Log Register 2 | RW | 00 | CustomerLogReg2[7:0] | | | | | | | |
| 2F | Customer Data Log Register 3 | RW | 00 | CustomerLogReg3[7:0] | | | | | | | |
| 40 | FAN Count Readout MSB | RO | 00 | FANIN[11:4] | | | | | | | |
| 41 | FAN Count Readout LSB | RO | 00 | FANIN[3:0] | | | | Reserved | | | |
| 42 | FAN Count High | RW | FF | FANIN_HL[11:4] | | | | | | | |

| Idx | Register Name | Attr | Dft | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Limit MSB | | | | | | | | | | |
| 43 | FAN Count High Limit LSB | RW | E0 | FANIN_HL[3:0] | | | | Reserved | | | |
| 44 | FanctrlDutyCycle | RW | 80 | FANDuty | | | | | | | |
| 45 | Configuration Register 1 | RW | 00 | Share_Sour_Temp2 | | Share_Sour_Temp1 | | EN_ShareMode | | EN_SpeedCruise | |
| 46 | Configuration Register 2 | RW | 10 | Reserved | | Temp2FanSelect | | Temp1FanSelect | | FanControlMode | |
| 47 | Configuration Register 3 | RW | A1 | PWMPOL | | Reserved | | Temp2_Sour_Sel | | Temp1_Sour_Sel | |
| 48 | Configuration Register 4 | RW | 00 | Reserved | | | | TwoDimension | SimpleMode | | FastTracking |
| 49 | Dynamic feature Register 1 | RW | 50 | Tcontrol | | | | | | | |
| 4A | Dynamic feature Register 2 | RW | 3C | Tbound | | | | | | | |
| 4B | Dynamic feature Register 3 | RW | 35 | DownFan_Tol_FanDuty | | | Weight_SYS | | | Reserved | |
| 4C | Dynamic feature Register 4 | RW | 52 | Unstable_Depth | | | StepCng_Up | | | StepCng_Down | |
| 4D | Dynamic feature Register 5 | RW | 02 | FCount_FDuty_Weight_High (Twodimension = 1) | | | | FCount_FDuty_Step_High (Twodimension = 1) | | | |
| 4E | Dynamic feature Register 6 | RW | 02 | FCount_FDuty_Weight_Mid (Twodimension = 1) | | | | FCount_FDuty_Step_Mid (Twodimension = 1) | | | |
| 4F | Dynamic feature Register 7 | RW | 04 | FCount_FDuty_Weight_Low (Twodimension = 1) | | | | FCount_FDuty_Step_Low (Twodimension = 1) | | | |
| 50 | Dynamic feature Register 8 | RW | 0A | Generic_Tol_FanInCount | | | | | | | |
| 51 | Dynamic feature Register 9 | RW | 99 | RPM_Boundary_High[7:0] | | | | | | | |
| 52 | Dynamic feature Register 10 | RW | 1C | RPM_Boundary_Low[7:0] | | | | | | | |
| 53 | Dynamic feature Register 11 | RW | 12 | RPM_Boundary_High[11:8] | | | | RPM_Boundary_Low[11:8] | | | |
| 54 | Dynamic feature Register 12 | RW | 05 | DownFan_Tol_ FanInCount_High[7:0] | | | | | | | |
| 55 | Dynamic feature Register 13 | RW | 0A | DownFan_Tol_FanInCount_Low[7:0] | | | | | | | |
| 56 | Fanctl Step Up Time | RW | 0A | UpTime | | | | | | | |
| 57 | Fanctl Step Down Time | RW | 0A | DownTime | | | | | | | |
| 58 | PWM1 Prescalar | RW | 84 | CKSEL | | | FanOutDivisor[6:0] | | | | |
| 59 | Fanctl Start Duty Cycle | RW | 30 | StartDutyCycle | | | | | | | |
| 5A | Fanctl Nonstop Duty Cycle | RW | 10 | NonStopDutyCycle | | | | | | | |
| 5B | Stop Time of Fanctl | RW | FF | StopTime | | | | | | | |
| 5C | FANIN Target speed (HB) | RW | 60 | TargetFanInCount[11:4] | | | | | | | |
| 5D | FANIN Target speed (LB) | RW | 00 | TargetFanInCount[3:0] | | | | Reserved | | | |
| 5E | Target Speed Tolerance | RW | 10 | Reserved | | | | TOL_FanInCount[5:0] | | | |
| 5F | Temp1 Target Temperature | RW | 46 | TargetTemp1 | | | | | | | |
| 60 | Temp2 Target Temperature | RW | 46 | TargetTemp2 | | | | | | | |
| 61 | Temp1 Hysteresis | RW | 2B | Reserved | | Criti_HysT1 | | | Oper_HysT1 | | |
| 62 | Temp2 Hysteresis | RW | 2B | Reserved | | Criti_HysT2 | | | Oper_HysT2 | | |

| Idx | Register Name | Attr | Dft | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|-----|---------------|------|-----|---|---|---|---|---|---|---|---|
| 63 | Table 1 Transition Point 1 | RW | 0A | | | | Temp1Table_TR1 | | | | |
| 64 | Table 1 Transition Point 2 | RW | 14 | | | | Temp1Table_TR2 | | | | |
| 65 | Table 1 Transition Point 3 | RW | 1E | | | | Temp1Table_TR3 | | | | |
| 66 | Table 1 Transition Point 4 | RW | 28 | | | | Temp1Table_TR4 | | | | |
| 67 | Table 1 Transition Point 5 | RW | 32 | | | | Temp1Table_TR5 | | | | |
| 68 | Table 1 Transition Point 6 | RW | 3C | | | | Temp1Table_TR6 | | | | |
| 69 | Table 1 Transition Point 7 | RW | 55 | | | | Temp1Table_TR7 | | | | |
| 6A | Table 1 Critical Point | RW | 5A | | | | Temp1Table_TRCritical | | | | |
| 6B | Table 1 Y-axis Transition Point 1 | RW | 28 | | | | Temp1Table_FL1 | | | | |
| 6C | Table 1 Y-axis Transition Point 2 | RW | 50 | | | | Temp1Table_FL2 | | | | |
| 6D | Table 1 Y-axis Transition Point 3 | RW | 78 | | | | Temp1Table_FL3 | | | | |
| 6E | Table 1 Y-axis Transition Point 4 | RW | 96 | | | | Temp1Table_FL4 | | | | |
| 6F | Table 1 Y-axis Transition Point 5 | RW | B4 | | | | Temp1Table_FL5 | | | | |
| 70 | Table 1 Y-axis Transition Point 6 | RW | D2 | | | | Temp1Table_FL6 | | | | |
| 71 | Table 1 Y-axis Transition Point 7 | RW | F0 | | | | Temp1Table_FL7 | | | | |
| 72 | Table 2 Transition Point 1 | RW | 19 | | | | Temp2Table_TR1 | | | | |
| 73 | Table 2 Transition Point 2 | RW | 1E | | | | Temp2Table_TR2 | | | | |
| 74 | Table 2 Transition Point 3 | RW | 23 | | | | Temp2Table_TR3 | | | | |
| 75 | Table 2 Transition Point 4 | RW | 28 | | | | Temp2Table_TR4 | | | | |
| 76 | Table 2 Transition Point 5 | RW | 2D | | | | Temp2Table_TR5 | | | | |
| 77 | Table 2 Transition Point 6 | RW | 32 | | | | Temp2Table_TR6 | | | | |
| 78 | Table 2 Transition Point 7 | RW | 37 | | | | Temp2Table_TR7 | | | | |
| 79 | Table 2 Critical Point | RW | 3C | | | | Temp2Table_TRCritical | | | | |
| 7A | Table 2 Y-axis Transition Point 1 | RW | 28 | | | | Temp2Table_FL1 | | | | |
| 7B | Table 2 Y-axis Transition Point 2 | RW | 50 | | | | Temp2Table_FL2 | | | | |
| 7C | Table 2 Y-axis Transition Point 3 | RW | 78 | | | | Temp2Table_FL3 | | | | |
| 7D | Table 2 Y-axis Transition Point 4 | RW | 96 | | | | Temp2Table_FL4 | | | | |
| 7E | Table 2 Y-axis Transition Point 5 | RW | B4 | | | | Temp2Table_FL5 | | | | |
| 7F | Table 2 Y-axis Transition Point 6 | RW | D2 | | | | Temp2Table_FL6 | | | | |
| 80 | Table 2 Y-axis Transition Point 7 | RW | F0 | | | | Temp2Table_FL7 | | | | |
| BF | RT Filter & Alert mode | RW | 00 | Reserved | | | RT1F | | | Alert_MD | |
| FD | CID (Chip ID) | RO | 50 | 50h | | | | | | | |

| Idx | Register Name | Attr | Dft | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| FE | VID (Vendor ID) | RO | 50 | 50h | | | | | | | |
| FF | DID (Device ID) | RO | 9x | 9xH (x=0,1,2…) | | | | | | | |

## 7.2 Register Detail

### 7.2.1 Local Diode Temperature Readout Register

Location : Address 00h

Type : Read Only

Power on default value : 00

| BIT | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|
| Name | Local Diode Temperature Readout Value. The real temperature value calculation is referred to TEMPERATURE MEASUREMENT DATA FORMAT. | | | | | | | |
| Value | SIGN | 64 | 32 | 16 | 8 | 4 | 2 | 1 |

### 7.2.2 Remote Diode 1 Temperature Readout (MSB) Register

Location : Address 01h

Type : Read Only

Power on default value : 00

| BIT | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|
| Name | Remote Diode 1 Temperature Readout Value. The real temperature value calculation is referred to TEMPERATURE MEASUREMENT DATA FORMAT. | | | | | | | |
| Value | SIGN | 64 | 32 | 16 | 8 | 4 | 2 | 1 |

### 7.2.3 Alert Status Register

Location : Address 02h

Type : Read Only

Power on default value : 00

| BIT | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|
| Name | ADC_Busy | STS_LTHA | Reserved | STS_RT1HA | STS_RT1LA | STS_RT1O | STS_RT1C | STS_TACH |
| Default | 0 | 0 | | 0 | 0 | 0 | 0 | 0 |

| BIT | FLAG NAME | DESCRIPTION |
|---|---|---|
| 7 | ADC_Busy | If set to '1' indicates ADC is busy converting. |
| 6 | STS_LTHA | If set to '1' indicates a measured Local Diode Temperature Higher than Local High set point (High Limit). |
| 5 | Reserved | |
| 4 | STS_RT1HA | If set to '1' indicates a measured Remote Diode1 Temperature higher than Remote High set point (High Limit). |

| BIT | FLAG NAME | DESCRIPTION |
|---|---|---|
| 3 | STS_RT1LA | If set to '1' indicates a measured Remote Diode1 Temperature lower than Remote Low set point (Low Limit). |
| 2 | STS_RT1O | If set to '1' indicates a Remote Diode1 disconnect. |
| 1 | STS_RT1C | If set to '1' indicates a Remote Diode1 Critical Temperature alarm. |
| 0 | STS_TACH | If set to '1' indicates Tachometer count is higher than Tachometer Limit. |

### 7.2.4   Configuration Register

Location : Address 03h and 09h

Type : Read/Write

Power on default value : 15

| BIT | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|
| Name | ALERT_ MSK | STOP_ Mnt | DIS_FA NOUT | EN_FAN IN | RESER VED | EN_RT1 | EN_WT C | EN_Faul tQueue |
| Default | 0 | 0 | 0 | 1 | | 1 | 0 | 1 |

| BIT | DESCRIPTION |
|---|---|
| 7 | **ALERT_MSK** – ALERT# function is enable<br>0 = Enable<br>1 = Disable |
| 6 | **STOP_Mnt** – Stop Monitor and entry Standby<br>0 = Monitor<br>1 = Stop Monitor |
| 5 | **DIS_FANOUT**– Disable PWM FANOUT.<br>0 = Enable PWM FANOUT<br>1 = Disable PWM FANOUT |
| 4 | **EN_FANIN**– Enable FANIN monitoring.<br>0 = Disable<br>1 = Enable |
| 2 | **EN_RT1** – Enable Remote Diode 1 monitoring.<br>0 = Disable<br>1 = Enable |
| 1 | **EN_WTC**– Enable Override POR Value of Critical Temperature<br>0 = Disable<br>1 = Enable |
| 0 | **EN_FaultQueue**– Enable Fault Queue function<br>0 = Disable. ALERT# and T_CRIT# will be generated if monitor result of any channel is above or below high/low setting point.<br>1 = Enable. ALERT# and T_CRIT# will be generated if monitor result of any channel is |

| BIT | DESCRIPTION |
|---|---|
| | consecuite three times above or below high/low setting point. |

### 7.2.5 Conversion Rate Register

Location : Address 04h and 0Ah

Type : Read/Write

Power on default value : 08

| BIT | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|
| Name | Reserved | | | | ConvRate | | | |
| Default | | | | | 1 | 0 | 0 | 0 |

| BIT<D7:D0> | FREQUENCY/TIME |
|---|---|
| 00h | 0.0625Hz / 16sec |
| 01h | 0.125Hz / 8sec |
| 02h | 0.25Hz / 4sec |
| 03h | 0.5Hz / 2sec |
| 04h | 1Hz / 1sec |
| 05h | 2Hz / 0.5sec |
| 06h | 4Hz / 0.25sec |
| 07h | 8Hz / 0.125sec |
| 08h | 16Hz / 0.0625sec |
| 09h-FFh | Reserved |

### 7.2.6 Local Diode Temperature Alert Temperature Register

Location : Address 05h and 0Bh

Type : Read/Write

Power on default value : 46

| BIT | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|
| Name | LDT Alert Temperature | | | | | | | |
| Value | SIGN | 64 | 32 | 16 | 8 | 4 | 2 | 1 |
| Default | $46_{HEX}$ (70℃) | | | | | | | |

### 7.2.7 Remote Diode 1 Temperature High Alert Temperature (MSB) Register

Location : Address 07h and 0Dh

Type : Read/Write

Power on default value : 46

| BIT | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|
| Name | RT1 High Alert Temperature High Byte | | | | | | | |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Value | SIGN | 64 | 32 | 16 | 8 | 4 | 2 | 1 |
| Default | $46_{HEX}$ (70℃) | | | | | | | |

### 7.2.8   Remote Diode 1 Temperature Low Alert Temperature (MSB) Register

Location : Address 08h and 0Eh

Type : Read/Write

Power on default value : D8

| BIT | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|
| Name | RT1 Low Alert Temperature High Byte | | | | | | | |
| Value | SIGN | 64 | 32 | 16 | 8 | 4 | 2 | 1 |
| Default | $D8_{HEX}$ (-40℃) | | | | | | | |

### 7.2.9   One Shot Conversion Register

Location : Address 0Fh

Type : Write Only

| BIT | DESCRIPTION |
|---|---|
| 7-0 | One Shot Conversion – When enter Stop Monitor state, to fill any value into this register will trigger one temperature conversion cycle. |

### 7.2.10  Remote Diode 1 Temperature Readout (LSB) Register

Location : Address 10h

Type : Read Only

Power on default value : 00

| BIT | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|
| Name | Remote Diode 1 Temperature Readout Value. The real temperature value calculation is referred to TEMPERATURE MEASUREMENT DATA FORMAT. | | | Reserved | | | | |
| Value | 0.5 | 0.25 | 0.125 | 0 | | | | |

### 7.2.11  Remote Diode 1 Temperature Offset Register (MSB) Register

Location : Address 11h

Type : Read/Write

Power on default value : 00

| BIT | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|
| Name | RT1 OFFSET VALEU High Byte | | | | | | | |
| Value | SIGN | 64 | 32 | 16 | 8 | 4 | 2 | 1 |
| Default | $00_{HEX}$ | | | | | | | |

### 7.2.12  Remote Diode 1 Temperature Offset Register (LSB) Register

Location : Address 12h

Type : Read/Write

Power on default value : 00

| BIT | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|
| Name | RT1 OFFSET VALUE Low Byte | | | | | | | |
| Value | 0.5 | 0.25 | 0.125 | | | | | |
| Default | 00$_{HEX}$ | | | | | | | |

### 7.2.13  Remote Diode 1 Temperature High Alert Temperature (LSB) Register

Location : Address 13h

Type : Read/Write

Power on default value : 00

| BIT | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|
| Name | RT1 High Alert Temperature Low Byte | | | | | | | |
| Value | 0.5 | 0.25 | 0.125 | | | | | |
| Default | 00$_{HEX}$ | | | | | | | |

### 7.2.14  Remote Diode 1 Temperature Low Alert Temperature (LSB) Register

Location : Address 14h

Type : Read/Write

Power on default value : 00

| BIT | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|
| Name | RT1 Low Alert Temperature Low Byte | | | | | | | |
| Value | 0.5 | 0.25 | 0.125 | | | | | |
| Default | 00$_{HEX}$ | | | | | | | |

### 7.2.15  Alert Mask Register

Location : Address 16h

Type : Read/Write

Power on default value : 06

| BIT | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|
| Name | MSK_LTH | Reserved | | MSK_RT1H | MSK_RT1L | Reserved | MSK_RT1C | MSK_TACH |
| Default | 0 | | | 0 | 0 | | 1 | 0 |

| BIT | DESCRIPTION |
|---|---|
| 7 | MSK_LTH – Local Diode Temperature High Alert Mask<br>0 = Alert is not masked |

| BIT | DESCRIPTION |
|---|---|
| | 1 = Alert is masked |
| 4 | MSK_RT1H– Remote Diode 1 Temperature High Alert Mask<br>0 = Alert is not masked<br>1 = Alert is masked |
| 3 | MSK_RT1L– Remote Diode 1 Temperature Low Alert Mask<br>0 = Alert is not masked<br>1 = Alert is masked |
| 1 | MSK_RT1C– Remote Diode 1 Temperature Critical Mask<br>0 = Alert is not masked<br>1 = Alert is masked |
| 0 | MSK_TACH– Fan Tachometer Alert Mask<br>0 = Alert is not masked<br>1 = Alert is masked |

### 7.2.16  Remote Diode 1 Critical Temperature Register

Location : Address 19h

Type : Read/Write

Power on default value : Power on trapping after power up 100ms

| BIT | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|
| Name | RT1 Critical Temperature<br>The format of Temperature is 8-bit 2's complement and the range is −128℃~127℃. | | | | | | | |
| Value | SIGN | 64 | 32 | 16 | 8 | 4 | 2 | 1 |
| Default | Hardware Strapping | | | | | | | |

The default value is trapping after power up 100ms by different pull-up resistors of ALERT# pin :

| PULL-UP RESISTOR | | TEMPERATURE (℃) |
|---|---|---|
| **ALERT#** | **2KΩ** | 75 |
| | **7.5KΩ** | 90 |
| | **10.5KΩ** | 100 |
| | **14KΩ** | 105 |
| | **18.7KΩ** | 110 |

### 7.2.17  Critical Temperature Hysteresis Register

Location : Address 21h

Type : Read/Write

Power on default value : 0A

| BIT | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|
| Name | Critical Temperature Hysteresis<br>The format of Temperature is 5-bit integer and the range is 0℃~31℃. | | | | | | | |
| Value | | | | 16 | 8 | 4 | 2 | 1 |
| Default | $0A_{HEX}$ (10℃) | | | | | | | |

### 7.2.18  Customer Data Log Registers

Location : Address 2Dh     2Eh     2Fh

Type : Read/Write

Power on default value : 00

| BIT | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|
| Name | Customer Data Log Register | | | | | | | |
| Default | $00_{HEX}$ | | | | | | | |

### 7.2.19  Fan Count Readout (MSB) Register

Location : Address 40h

Type : Read Only

Power on default value : 00

| BIT | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|
| Name | FANIN tachometer readout high byte. The real FANIN RPM value calculation is referred to FANIN COUNT CACLULATION description.<br>12-bitCount Value bit[11:4] | | | | | | | |

### 7.2.20  Fan Count Readout (LSB) Register

Location : Address 41h

Type : Read Only

Power on default value : 00

| BIT | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|
| Name | FANIN tachometer readout low byte<br>12-bitCount Value bit [3:0] | | | | Reserved. | | | |

**7.2.21  Fan Count High Limit (MSB) Register**

Location : Address 42h

Type : Read/Write

Power on default value : FF

| BIT | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|
| Name | FANIN_HL<br><br>FANIN tachometer count limit (high byte). The real FANIN RPM count limit value calculation is referred to FANIN COUNT CACLULATION description.<br><br>12-bitCount Value bit[11:4] |||||||| |
| Default | $FF_{HEX}$ |||||||| |

**7.2.22  Fan Count High Limit (LSB) Register**

Location : Address 43h

Type : Read/Write

Power on default value : EE

| BIT | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|
| Name | FANIN_HL_LSB |||| Reversed |||| |
| | FANIN tachometer count limit (lowe byte).<br><br>12-bitCount Value bit [3:0] |||||||| |
| Default | $EE_{HEX}$ |||||||| |

**7.2.23  Fanctrl Duty Cycle Register**

Location : Address 44h

Type : Read / Write (in Manual Mode)

   Read Only (in the Smart Fan mode)

Power on default value : 80

| BIT | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|
| Name | FANDuty |||||||| |
| Default | $80_{HEX}$ |||||||| |

| BIT | DESCRIPTION |
|---|---|
| 7-0 | FANDuty – Current Fanctrl output value.<br>In Manual Mode, programming this register to set desired PWM duty cycle.<br>In Thermal Cruise or SMART FAN™ IV algorithm, this register reveals the current PWM duty cycle and is Read Only. |

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### 7.2.24 Generic Fan Control Configuration Register 1 (GFCCR1) Register

Location : Address 45h

Type : Read/Write

Power on default value : 00

| BIT | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|-----|---|---|---|---|---|---|---|---|
| Name | Share_Sour_Temp2 | | | Share_Sour_Temp1 | | | EN_ShareMode | EN_SpeedCruise |
| Default | $00_{HEX}$ | | | | | | | |

| BIT | DESCRIPTION |
|-----|-------------|
| 7-5 | Share_Sour_Temp2 : Select which temperature source could share control table in SMART FAN$^{TM}$ IV mode<br>001 : Local temperature will be referred to SMART FAN$^{TM}$ IV control table 2<br>010 : Remote 1 temperature will be referred to SMART FAN$^{TM}$ IV control table 2<br>Others : Reserved |
| 4-2 | Share_Sour_Temp1 : Select which temperature source could share control table in SMART FAN$^{TM}$ IV mode<br>001 : Local temperature will be referred to SMART FAN$^{TM}$ IV control table 1<br>010 : Remote 1 temperature will be referred to SMART FAN$^{TM}$ IV control table 1<br>Others : Reserved |
| 1 | EN_ShareMode : Enable sharing table function in SMART FAN$^{TM}$ IV control mode<br>0 = Disable<br>1 = Enable |
| 0 | EN_SpeedCruise : Apply Speed Cruise$^{TM}$ mode to FANCTL<br>0 = Fan control mode is decide by GFCCR2 register. (Default)<br>1 = FANCTL is applies to Speed Cruise$^{TM}$ control for FANIN speed input. |

### 7.2.25 Generic Fan Control Configuration Register 2 (GFCCR2) Register

Location : Address 46h

Type : Read/Write

Power on default value : 10

| BIT | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|-----|---|---|---|---|---|---|---|---|
| Name | Reserved | | | | Temp2FanSelect | Temp1FanSelect | FanControlMode | |
| Default | $10_{HEX}$ | | | | | | | |

| BIT | DESCRIPTION |
|-----|-------------|
| 7-4 | Reserved. |

| BIT | DESCRIPTION |
|---|---|
| 3 | Temp2 FanSelect : Decide temp2 whether effect FANCTRL or not.<br>0 = Independent<br>1 = Dependent |
| 2 | Temp1 FanSelect : Decide temp1 whether effect FANCTRL or not.<br>0 = Independent<br>1 = Dependent |
| 1-0 | FanControlMode : From temperature view, decide Fan Control mode<br>00 : Temp2 & Temp1 practice thermal cruise algorithm<br>01: Temp2 practices thermal cruise algorithm and Temp1 is SMART FAN<sup>TM</sup> IV algorithm<br>Others : Reserved |

### 7.2.26 Generic Fan Control Configuration Register 3 (GFCCR3) Register

Location : Address 47h

Type : Read/Write

Power on default value : A1

| BIT | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|
| Name | PWMPOL | Reserved | Temp2_Sour_Sel | | | Temp1_Sour_Sel | | |
| Default | $A1_{HEX}$ | | | | | | | |

| BIT | DESCRIPTION |
|---|---|
| 7 | PWMPOL : Control FANCTL PWM output polarity.<br>0 = Low active. PWM is controlled by negative duty cycle.<br>1 = High active. (Default). PWM is controlled by positive duty cycle. |
| 6 | Reserved |
| 5-3 | Temp2_Sour_Sel : Temperature source selection for Table2 in SMART FAN<sup>TM</sup> IV algorithm<br>001 = Local temperature<br>010 = Remote temperature 1<br>Others : Reserved |
| 2-0 | Temp1_Sour_Sel : Temperature source selection for Table1 in SMART FAN<sup>TM</sup> IV algorithm<br>001 = Local temperature<br>010 = Remote temperature 1<br>Others : Reserved |

### 7.2.27 Generic Fan Control Configuration Register 4 (GFCCR4) Register

Location : Address 48h

Type : Read/Write

Power on default value : 00

| BIT | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|
| Name | Reserved | | | | | TwoDimension | SimpleMode | FastTracking |
| Default | $00_{HEX}$ | | | | | | | |

| BIT | DESCRIPTION |
|---|---|
| 7-3 | Reserved |
| 2 | TwoDimension : Close-Loop Fan Control mode ( RPM to Temperature ) enabling<br>1 = RPM to Temperature control<br>0 = FanDuty to Temperature control |
| 1 | SimpleMode : Select the type of Fan Duty change rate. It's available only with Fast Tracking = 1.<br>0 : Fan Duty change rate is dynamic<br>1 : Fan Duty change rate is programmable. Set by StepCng_Up & StepCng_Down |
| 0 | FastTracking : Enable fast tracking mode<br>0 : Fan Duty change rate is one step.<br>1 : Fan Duty change rate is programmable or dynamic depended on Simple Mode |

### 7.2.28 Dynamic Close Loop Fan Control Configuration Registers

Location : Address 49h  4Ah  4Bh  4Ch  4Dh  4Eh  4Fh  50h  51h  52h  53h  54h  55h

Type : Read/Write

Power on default value : Refer to below tables

**Address 49h**

| BIT | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|
| Name | Tcontrol | | | | | | | |
| Default | $50_{HEX}$ | | | | | | | |

| BIT | DESCRIPTION |
|---|---|
| 7-0 | **Tcontrol :** Once CPU temperature is over this setting, dynamic fan duty change rate is activated |

**Address 4Ah**

| BIT | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|
| Name | Tbound | | | | | | | |
| Default | $3C_{HEX}$ | | | | | | | |

| BIT | DESCRIPTION |
|---|---|
| 7-0 | Tbound : Once System temperature is over this setting, dynamic fan duty change rate is activated |

**Address 4Bh**

| BIT | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|
| Name | DownFan_Tol_FanDuty | | | | Weight_SYS | | Reserved | |
| Default | $35_{HEX}$ | | | | | | | |

| BIT | DESCRIPTION |
|---|---|
| 7 - 4 | DownFan_Tol_FanDuty : Tracking tolerance of FanDuty while FanDuty is decreasing<br><br>1111 : 15　/ .... /　0000 : 0<br><br>Ex : Setting 3 => Final FanDuty = (Target FanDuty + 3)　while FanDuty is descending. |
| 3 – 2 | Weight_STS : Multiplication factor of System fan; the tracking speed of CPU fan responds to this setting.<br>00 : 0.25<br>01 : 0.5<br>10 : 1<br>11 : 2 |
| 1 - 0 | Reserved |

**Address 4Ch**

| BIT | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|
| Name | Reserved | | StepCng_Up | | | StepCng_Down | | |
| Default | $52_{HEX}$ | | | | | | | |

| BIT | DESCRIPTION |
|---|---|
| 7 - 6 | Reserved |
| 5 - 3 | StepCng_Up : Fixed increasing step of fan duty; only available with Simple Mode = 1 |
| 2 - 0 | StepCng_Down : Fixed decreasing step of fan duty; only available with Simple Mode = 1 |

**Address 4Dh**

| BIT | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|
| Name | FCount_FDuty_Weight_High | | FCount_FDuty_Step_High | | | | | |
| Default | $02_{HEX}$ | | | | | | | |
| Bit | Description | | | | | | | |
| 7 - 6 | FCount_FDuty_Weight_High : Multiplication factor of dynamic fan duty change rate for high RPM input | | | | | | | |
| 5 - 0 | FCount_FDuty_Step_High : Addition factor of dynamic fan duty change rate for high RPM input | | | | | | | |

**Address 4Eh**

| BIT | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|
| Name | FCount_FDuty_Weight_Mid | | FCount_FDuty_Step_Mid | | | | | |
| Default | $02_{HEX}$ | | | | | | | |

| BIT | DESCRIPTION |
|---|---|
| 7 - 6 | FCount_FDuty_Weight_Mid : Multiplication factor of dynamic fan duty change rate for middle RPM input |
| 5 - 0 | FCount_FDuty_Step_Mid : Addition factor of dynamic fan duty change rate for middle RPM input |

**Address 4Fh**

| BIT | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|
| Name | FCount_FDuty_Weight_Low | | FCount_FDuty_Step_Low | | | | | |
| Default | $04_{HEX}$ | | | | | | | |

| BIT | DESCRIPTION |
|---|---|
| 7 - 6 | FCount_FDuty_Weight_Low : Multiplication factor of dynamic fan duty change rate for low RPM input |
| 5 - 0 | FCount_FDuty_Step_Low : Addition factor of dynamic fan duty change rate for low RPM input |

**Address 50h**

| BIT | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|
| Name | Generic_Tol_FanInCount | | | | | | | |
| Default | 0A$_{HEX}$ | | | | | | | |

| BIT | DESCRIPTION |
|---|---|
| 7 - 0 | Generic_Tol_FanInCount : Tracking tolerance of input Fan Count under Two Dimension = 1<br>Ex : Setting 3 =><br>If current FANIN count = (Target FANIN count - 3) ~ (Target FANIN count + 3) then FanDuty will be maintained |

**Address 51h**

| BIT | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|
| Name | RPM_Boundary_High[7:0] | | | | | | | |
| Default | 99$_{HEX}$ | | | | | | | |

| BIT | DESCRIPTION |
|---|---|
| 7 - 0 | RPM_Boundary_High[7:0] : Low byte of high RPM speed boundary setting. It must be fan count format<br>Ex : Fan Count = 1350,000 / RPM |

**Address 52h**

| BIT | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|
| Name | RPM_Boundary_Low[7:0] | | | | | | | |
| Default | 1C$_{HEX}$ | | | | | | | |

| BIT | DESCRIPTION |
|---|---|
| 7 - 0 | RPM_Boundary_Low[7:0] : Low byte of low RPM speed boundary setting. It must be fan count format<br>Ex : Fan Count = 1350,000 / RPM |

**Address 53h**

| BIT | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|
| Name | RPM_Boundary_High[11:8] | | | | RPM_Boundary_Low[11:8] | | | |
| Default | 12$_{HEX}$ | | | | | | | |

| BIT | DESCRIPTION |
|---|---|
| 7 - 0 | RPM_Boundary_High[11:8] : High byte of high RPM speed boundary setting. It must be fan count format<br>RPM_Boundary_Low[11:8] : High byte of low RPM speed boundary setting. It must be fan count format |

| BIT | | Ex : Fan Count = 1350,000 / RPM | | | | | | |

**Address 54h**

| BIT | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|
| Name | DownFan_Tol_FanInCount_High | | | | | | | |
| Default | 05$_{HEX}$ | | | | | | | |

| BIT | DESCRIPTION |
|---|---|
| 7 - 0 | DownFan_Tol_FanInCount_High : Tracking tolerance of input Fan Count under high RPM speed with<br><br>Two Dimension = 1 & Fast Tracking = 1<br><br>Ex : Setting 3 =><br><br>If the current FANIN count reaches (Target FANIN count - 3) then tracking stops |

**Address 55h**

| BIT | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|
| Name | DownFan_Tol_FanInCount_Low | | | | | | | |
| Default | 0A$_{HEX}$ | | | | | | | |

| BIT | DESCRIPTION |
|---|---|
| 7 - 0 | DownFan_Tol_FanInCount_Low : Tracking tolerance of input Fan Count under low RPM speed with<br><br>Two Dimension = 1 & Fast Tracking = 1<br><br>Ex : Setting 3 =><br><br>If the current FANIN count reaches (Target FANIN count - 3) then tracking stops |

### 7.2.29 SMART FAN<sup>TM</sup> IV Control Output Step Up Time Register

Location : Address 56h

Type : Read/Write

Power on default value : 0A

| BIT | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|
| Name | UpTime (Smart Fan Step Up Time). Unit in 0.1sec. Programmed as the interval of continuous Fan ramping up. | | | | | | | |
| Default | 0A$_{HEX}$ | | | | | | | |

This register should not be set to 0. Otherwise, the fan duty will be abnormal.

### 7.2.30 SMART FAN™ IV Control Output Step Down Time Register

Location : Address 57h

Type : Read/Write

Power on default value : 0A

| BIT | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|
| Name | DownTime (Smart Fan Step Down Time). Unit in 0.1sec. Programmed as the interval of continuous Fan ramping Down. |
| Default | 0A$_{HEX}$ |

This register should not be set to 0. Otherwise, the fan duty will be abnormal.

### 7.2.31 Fan Output PWM Frequency Prescalar Register

Location : Address 58h

Type : Read/Write

Power on default value : 84

| BIT | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|
| Name | CKSEL | FanOutDivisor | | | | | | |
| Default | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 0 |

A wide range of clocks can be selected to satisfy customer needs. The default output frequency is around 25 KHz.

| BIT | DESCRIPTION |
|---|---|
| 7 | CLKSEL / BASE Frequency: 0 = 1.024KHz, 1 = 125KHz |
| 6-0 | Divisor – Clock frequency Divisor. |

There are 2 divisors depending on CKSEL :

If CKSEL equals **1**, then the output clock is simply equal to **125/ (Divisor+1) KHz .**

If CKSEL equals **0**, the output clock is **1.024KHz/MappedDivisor**.

MappedDivisor depends on **Divisor[3:0]** and is described in the table below.

| DIVISOR[3:0] | MAPPED DIVISOR | OUTPUT FREQUENCY | DIVISOR[3:0] | MAPPED DIVISOR | OUTPUT FREQUENCY |
|---|---|---|---|---|---|
| 0000 | 1 | 1024Hz | 1000 | 12 | 85Hz |
| 0001 | 2 | 512Hz | 1001 | 16 | 64Hz |
| 0010 | 3 | 341Hz | 1010 | 32 | 32Hz |
| 0011 | 4 | 256Hz | 1011 | 64 | 16Hz |
| 0100 | 5 | 205Hz | 1100 | 128 | 8Hz |
| 0101 | 6 | 171Hz | 1101 | 256 | 4Hz |
| 0110 | 7 | 146Hz | 1110 | 512 | 2Hz |

| DIVISOR[3:0] | MAPPED DIVISOR | OUTPUT FREQUENCY | DIVISOR[3:0] | MAPPED DIVISOR | OUTPUT FREQUENCY |
|---|---|---|---|---|---|
| **0111** | 8 | 128Hz | **1111** | 1024 | 1Hz |

### 7.2.32  Fan Output Start-up Value Register

Location : Address 59h

Type : Read/Write

Power on default value : 30

| BIT | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|
| Name | FanStartDuty | | | | | | | |
| Default | $30_{HEX}$ | | | | | | | |

| BIT | DESCRIPTION |
|---|---|
| 7-0 | **FanStartDuty –**control the FANCTL fan output start-up value. |

### 7.2.33  Fan Output Nonstop Value Register

Location : Address 5Ah

Type : Read/Write

Power on default value : 10

| BIT | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|
| Name | FanNonStop | | | | | | | |
| Default | $10_{HEX}$ | | | | | | | |

| BIT | DESCRIPTION |
|---|---|
| 7-0 | FanNonStop – control the FANCTL fan output nonstop value. |

### 7.2.34  Fan Output Stop Time Register

Location : Address 5Bh

Type : Read/Write

Power on default value : FF

| BIT | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|
| Name | FanStopTime | | | | | | | |
| Default | $FF_{HEX}$ | | | | | | | |

| BIT | DESCRIPTION |
|---|---|
| 7-0 | FanStopTime – control the FANCTL fan stop time from Fan Output Nonstop Value to the off state. Unit in 0.1sec. Ranges from 0.1sec to 25.5sec. |

| | If set to 0, the fan will never stop. |
|---|---|

### 7.2.35 FANIN Target Speed Register

Location : Address 5Ch 5Dh

Type : Read/Write

Power on default value : Refer to below tables

**FANIN Target Speed High Byte**

| BIT | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|
| Name | FTSH : FANIN tachometer target speed high byte. The real FANIN RPM value calculation is referred to FANIN COUNT CACLULATION description. 12-bitCount Value bit[11:4] | | | | | | | |
| Default | $60_{HEX}$ | | | | | | | |

**FANIN Target Speed Low Byte**

| BIT | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|
| Name | FTSL: FANIN tachometer target speed low byte. 12-bitCount Value bit [3:0] | | | | Reserved. | | | |
| Default | $00_{HEX}$ | | | | | | | |

In Fan Speed Cruise™ mode, each FANIN tachometer has to have a target fan speed. The NCT7509 will try to tune relative fan output to keep the fan speed of target. The default target speed for FANIN tachometer is $6000_{HEX}$ .

### 7.2.36 Tolerance of FANIN Target Speed Register

Location : Address 5Eh

Type : Read/Write

Power on default value : 10

| BIT | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|
| Name | Reserved | | Tolerance of FANIN Target Speed | | | | | |
| Default | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 |

| BIT | DESCRIPTION |
|---|---|
| 7-6 | Reserved. |
| 5-0 | Tolerance of FANIN Target Speed Tolerance of FANIN tachometer target speed. Tolerance range is 00h~3Fh |

### 7.2.37  Target Temperature of Temperature Input 1 Register

Location : Address 5Fh

Type : Read/Write

Power on default value : 46

| BIT | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|
| Name | Temp1 Target Temperature. | | | | | | | |
| Default | $46_{HEX}$  (70℃) | | | | | | | |

In Thermal Cruise™ mode, each temperature source has to have a target temperature. The NCT7509 will try to tune the fan output to keep the temperature of the target device around the target temperature.

### 7.2.38  Target Temperature of Temperature Input 2 Register

Location : Address 60h

Type : Read/Write

Power on default value : 46

| BIT | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|
| Name | Temp2 Target Temperature. | | | | | | | |
| Default | $46_{HEX}$  (70℃) | | | | | | | |

In Thermal Cruise™ mode, each temperature source has to have a target temperature. The NCT7509 will try to tune the fan output to keep the temperature of the target device around the target temperature.

### 7.2.39  Hysteresis of Temperature Input 1 Register

Location : Address 61h

Type : Read/Write

Power on default value : 2B

| BIT | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|
| Name | Reserved | | Hysteresis of Critical Temperature | | | Hysteresis of Operation Temperature | | |
| Default | 00 | | $5_{HEX}$  (5℃) | | | $3_{HEX}$  (3℃) | | |

| BIT | DESCRIPTION |
|---|---|
| 7-6 | Reserved |
| 5-3 | Set the hysteresis tolerance temperature of SMART FAN™ IV Algorithm<br>000 : 0 ℃<br>001 : 1 ℃<br>010 : 2 ℃<br>011 : 3 ℃<br>.... |

| BIT | DESCRIPTION |
|---|---|
| | 111 : 7 ℃ |
| 2-0 | Set the hysteresis tolerance temperature of SMART FAN™ IV Algorithm<br>000 : 0 ℃<br>001 : 1 ℃<br>010 : 2 ℃<br>011 : 3 ℃<br>....<br>111 : 7 ℃ |

In Thermal Cruise and SMART FAN™ IV mode, to prevent unstable temperatures from throttling the fan speed, the NCT7509 employs a hysteresis temperature to separate the speed-up/slow-down temperature points.

### 7.2.40  Hysteresis of Temperature Input 2 Register

Location : Address 62h

Type : Read/Write

Power on default value : 2B

| BIT | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|
| Name | Reserved | | Hysteresis of Critical Temperature | | | Hysteresis of Operation Temperature | | |
| Default | 00 | | $5_{HEX}$  (5℃) | | | $3_{HEX}$  (3℃) | | |

| BIT | DESCRIPTION |
|---|---|
| 7-6 | Reserved |
| 5-3 | Set the hysteresis tolerance temperature of SMART FAN™ IV Algorithm<br>000 : 0 ℃<br>001 : 1 ℃<br>010 : 2 ℃<br>011 : 3 ℃<br>....<br>111 : 7 ℃ |
| 2-0 | Set the hysteresis tolerance temperature of SMART FAN™ IV Algorithm<br>000 : 0 ℃<br>001 : 1 ℃<br>010 : 2 ℃<br>011 : 3 ℃<br>....<br>111 : 7 ℃ |

In Thermal Cruise and SMART FAN<sup>TM</sup> IV mode, to prevent unstable temperatures from throttling the fan speed, the NCT7509 employs a hysteresis temperature to separate the speed-up/slow-down temperature points.

### 7.2.41 SMART FAN<sup>TM</sup> IV Temperature and PWM Registers Register

Location : Address 63h ⁓ 80h

Type : Read/Write

Power on default value: Refer to below tables

SMART FAN<sup>TM</sup>IV is an algorithm providing a table mapping mechanism to translate the temperature information into output fan duties or desired Fan speed. The mapping table requires 2 domains for the translation. In the table, a certain temperature corresponds to a certain duty or RPM. T1-T7 (Temperature) and PWM1-PWM7 (PWM fan output values) are used to define the table. There are totally two tables reside in the NCT7509.

Relative Register-at SMART FAN<sup>TM</sup> IV Control Mode Table

| TABLE | NAME | ADDRESS | DEFAULT | TYPE |
|---|---|---|---|---|
| Table1 | Transition Point : **T1** | 63$_{HEX}$ | 0A$_{HEX}$ | Read/Write |
| | Transition Point : **T2** | 64$_{HEX}$ | 14$_{HEX}$ | Read/Write |
| | Transition Point : **T3** | 65$_{HEX}$ | 1E$_{HEX}$ | Read/Write |
| | Transition Point : **T4** | 66$_{HEX}$ | 28$_{HEX}$ | Read/Write |
| | Transition Point : **T5** | 67$_{HEX}$ | 32$_{HEX}$ | Read/Write |
| | Transition Point : **T6** | 68$_{HEX}$ | 3C$_{HEX}$ | Read/Write |
| | Transition Point : **T7** | 69$_{HEX}$ | 55$_{HEX}$ | Read/Write |
| | **Critical Point** | 6A$_{HEX}$ | 5A$_{HEX}$ | Read/Write |
| | Y-axis Transition Point : **PWM1** | 6B$_{HEX}$ | 28$_{HEX}$ | Read/Write |
| | Y-axis Transition Point : **PWM2** | 6C$_{HEX}$ | 50$_{HEX}$ | Read/Write |
| | Y-axis Transition Point : **PWM3** | 6D$_{HEX}$ | 78$_{HEX}$ | Read/Write |
| | Y-axis Transition Point : **PWM4** | 6E$_{HEX}$ | 96$_{HEX}$ | Read/Write |
| | Y-axis Transition Point : **PWM5** | 6F$_{HEX}$ | B4$_{HEX}$ | Read/Write |
| | Y-axis Transition Point : **PWM6** | 70$_{HEX}$ | D2$_{HEX}$ | Read/Write |
| | Y-axis Transition Point : **PWM7** | 71$_{HEX}$ | F0$_{HEX}$ | Read/Write |
| Table2 | Transition Point : **T1** | 72$_{HEX}$ | 19$_{HEX}$ | Read/Write |
| | Transition Point : **T2** | 73$_{HEX}$ | 1E$_{HEX}$ | Read/Write |
| | Transition Point : **T3** | 74$_{HEX}$ | 23$_{HEX}$ | Read/Write |
| | Transition Point : **T4** | 75$_{HEX}$ | 28$_{HEX}$ | Read/Write |
| | Transition Point : **T5** | 76$_{HEX}$ | 2D$_{HEX}$ | Read/Write |
| | Transition Point : **T6** | 77$_{HEX}$ | 32$_{HEX}$ | Read/Write |
| | Transition Point : **T7** | 78$_{HEX}$ | 37$_{HEX}$ | Read/Write |
| | **Critical Point** | 79$_{HEX}$ | 3C$_{HEX}$ | Read/Write |
| | Y-axis Transition Point : **PWM1** | 7A$_{HEX}$ | 28$_{HEX}$ | Read/Write |
| | Y-axis Transition Point : **PWM2** | 7B$_{HEX}$ | 50$_{HEX}$ | Read/Write |
| | Y-axis Transition Point : **PWM3** | 7C$_{HEX}$ | 78$_{HEX}$ | Read/Write |

| TABLE | NAME | ADDRESS | DEFAULT | TYPE |
|---|---|---|---|---|
| | Y-axis Transition Point : **PWM4** | 7D$_{HEX}$ | 96$_{HEX}$ | Read/Write |
| | Y-axis Transition Point : **PWM5** | 7E$_{HEX}$ | B4$_{HEX}$ | Read/Write |
| | Y-axis Transition Point : **PWM6** | 7F$_{HEX}$ | D2$_{HEX}$ | Read/Write |
| | Y-axis Transition Point : **PWM7** | 80$_{HEX}$ | F0$_{HEX}$ | Read/Write |

**T1 – T7**

| BIT | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|
| Name | SMART FAN$^{TM}$ IV Temperature | | | | | | | |
| Default | Refer to SMART FAN$^{TM}$ IV Control Mode Table | | | | | | | |

**PWM1 – PWM7**

| BIT | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|
| Name | SMART FAN$^{TM}$ IV PWM | | | | | | | |
| Default | Refer to SMART FAN$^{TM}$ IV Control Mode Table | | | | | | | |

### 7.2.42 Remote Diode Temperature Filter and Alert Mode Setting Register

Location : Address BFh

Type : Read/Write

Power on default value : 00

| BIT | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|---|
| Name | Reserved | | | | | RT1F | | ALERT_MD |
| Default | 00$_{HEX}$ | | | | | | | |

| BIT | DESCRIPTION |
|---|---|
| 2-1 | RT1F – Remote diode temperature 1 filter setting<br>00 = No filter selected<br>01 or 10 = Filter level 1 selected<br>11 = Filter level 2 selected |
| 0 | ALERT_MD – ALERT mode configuration<br>0 = Interrupt or SMBus$^{TM}$ alert mode<br>1 = Comparator mode |

### 7.2.43 Chip ID Register

Location : Address FDh

Type : Read Only

Power on default value : 50

| BIT | DESCRIPTION |
|---|---|

| BIT | DESCRIPTION |
|-----|-------------|
| 7-0 | **Chip ID.**<br>Chip ID of NCT7509 is 50$_{HEX}$ |

### 7.2.44 Vendor ID Register

Location : Address FEh

Type : Read Only

Power on default value : 50

| BIT | DESCRIPTION |
|-----|-------------|
| 7-0 | **Vendor ID.**<br>Vendor ID of NCT7509 is 50$_{HEX}$ |

### 7.2.45 Device ID Register

Location : Address FFh

Type : Read Only

Power on default value : 9x

| BIT | DESCRIPTION |
|-----|-------------|
| 7-0 | **Device ID.**<br>Device ID of NCT7509 is 9x$_{HEX}$  (x=0,1,2…) |

## 8. ELECTRICAL CHARACTERISTICS

### 8.1 Absolute Maximum Ratings

| PARAMETER | RATING | UNIT |
|---|---|---|
| Power Supply Voltage | $3.3V \pm 5\%$ | V |
| Input Voltage | -0.3 to +3.6 | V |
| Operating Temperature | -40 to +125 | $^\circ$ C |
| Storage Temperature | -55 to +150 | $^\circ$ C |

Note: Exposure to conditions beyond those listed under Absolute Maximum Ratings may adversely affect the life and reliability of the device.

### 8.2 DC Characteristics

(Ta = $0^\circ$ C to $70^\circ$ C, VDD = $3.3V \pm 5\%$, GND = 0V)

| PARAMETER | SYM. | MIN. | TYP. | MAX. | UNIT | CONDITIONS |
|---|---|---|---|---|---|---|
| $OD_{12}$ – Open-drain output pin with source-sink capability of 12 mA | | | | | | |
| Output Low Voltage | $V_{OL}$ | | | 0.4 | V | $I_{OL}$ = 12 mA |
| $IN_{ts}$ - TTL level Schmitt-triggered input pin | | | | | | |
| Input Low Voltage | $V_{IL}$ | | | 0.8 | V | VDD = 3.3V |
| Input High Voltage | $V_{IH}$ | 2.0 | | | V | VDD = 3.3V |
| Input High Leakage | $I_{LIH}$ | | | +10 | $\mu$A | VIN=3.3V |
| Input Low Leakage | $I_{LIL}$ | | | -10 | $\mu$A | VIN=0V |

## 8.3 AC Characteristics

### SMBus™ Interface
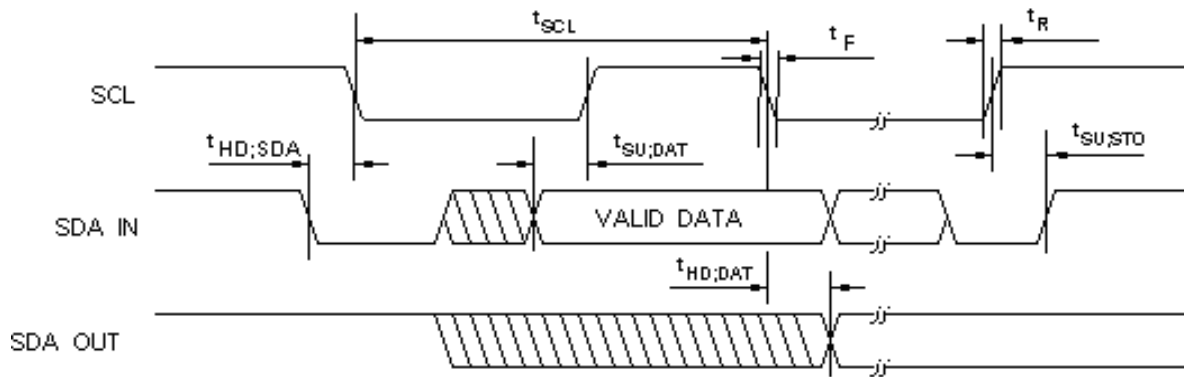


Serial Bus Timing Diagram

| PARAMETER | SYMBOL | MIN. | MAX. | UNIT |
|---|---|---|---|---|
| SCL clock period | $t_{SCL}^-$ | 2.5 | | uS |
| Start condition hold time | $t_{HD;SDA}$ | 1.5 | | uS |
| Stop condition setup-up time | $t_{SU;STO}$ | 1 | | uS |
| DATA to SCL setup time | $t_{SU;DAT}$ | 120 | | nS |
| DATA to SCL hold time | $t_{HD;DAT}$ | 5 | | nS |
| SCL and SDA rise time | $t_R$ | | 1.0 | uS |
| SCL and SDA fall time | $t_F$ | | 300 | nS |

## 9. ORDERING INFORMATION

| PART NO. | PACKAGE | SUPPLIED AS | PRODUCTION FLOW |
|---|---|---|---|
| NCT7509Y | DFN, 10pin<br>Green package | T Shape:<br>5,000 units/T&R | Commercial, 0℃ to +70℃ |
| NCT7509W | MSOP, 10pin<br>Green package | T Shape:<br>4,000 units/T&R | Commercial, 0℃ to +70℃ |

## 10. TOP MARKING SPECIFICATION

```
┌──────────────────┐        ┌──────────────────┐
│    7509Y         │        │    7509W         │
│    022GB         │        │    022GB         │
│  ●               │        │  ●               │
└──────────────────┘        └──────────────────┘
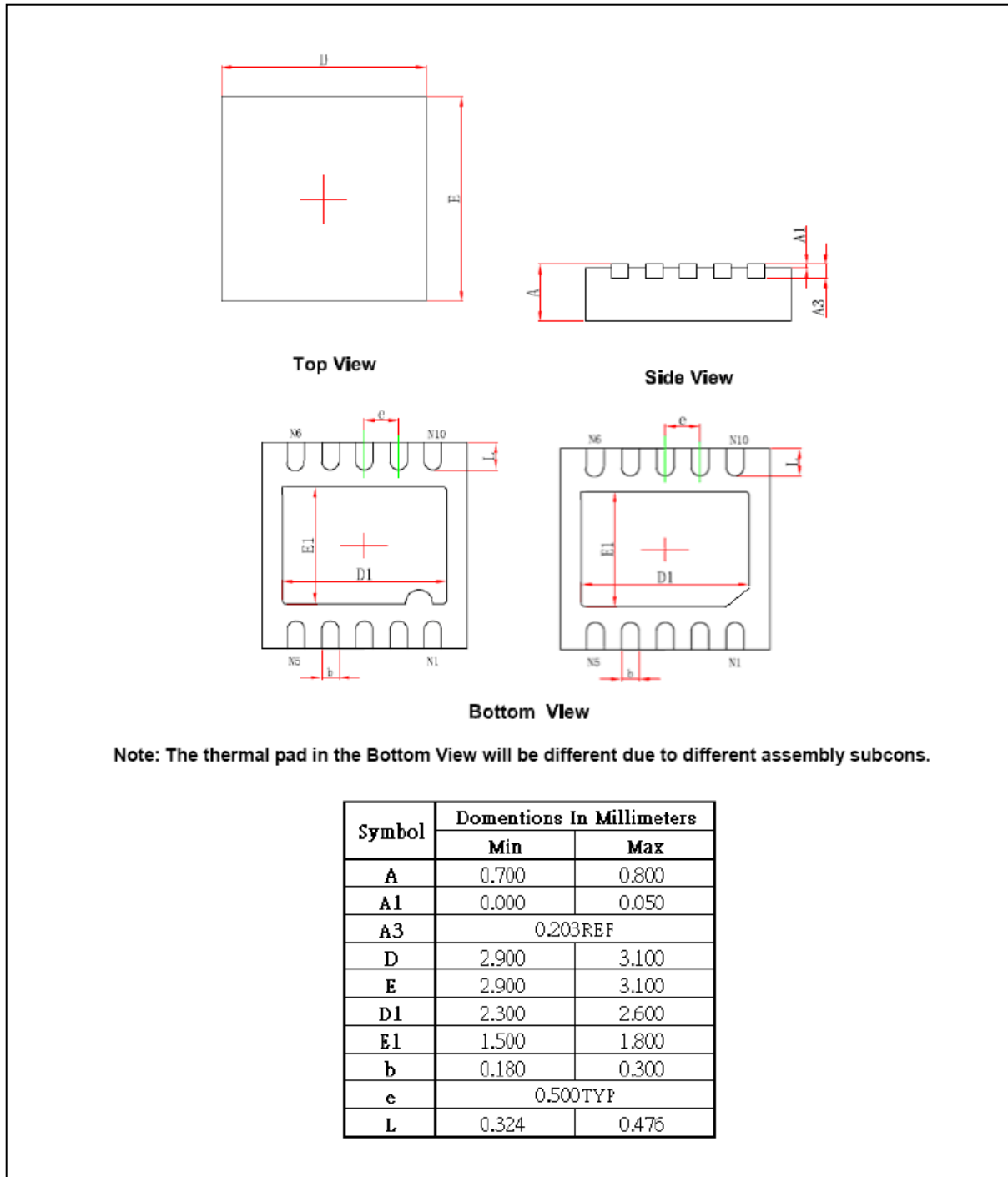```

1ˢᵗ line: Part number:    **7509Y** means the NCT7509Y
                          **7509W** means the NCT7509W


2ⁿᵈ line: Assembly tracking code

**0 22:** packages made in year 2010, week 22

**G:** Assembly house code

**B:** Product version

## 11. PACKAGE DRAWING AND DIMENSIONS

### 11.1 10L DFN (3X3 MM^2; 0.8 MM)



**Top View**

**Side View**

**Bottom View**

Note: The thermal pad in the Bottom View will be different due to different assembly subcons.

| Symbol | Domentions In Millimeters | |
|---|---|---|
| | Min | Max |
| A | 0.700 | 0.800 |
| A1 | 0.000 | 0.050 |
| A3 | 0.203REF | |
| D | 2.900 | 3.100 |
| E | 2.900 | 3.100 |
| D1 | 2.300 | 2.600 |
| E1 | 1.500 | 1.800 |
| b | 0.180 | 0.300 |
| e | 0.500TYP | |
| L | 0.324 | 0.476 |

## 11.2 10L MSOP (3X3 MM^2)



CONTROLLING DIMENSION:MILLIMETERS

| SYMBOL | DIMENSION IN MM | | | DIMENSION IN INCH | | |
|---|---|---|---|---|---|---|
| | MIN. | NOM. | MAX. | MIN. | NOM. | MAX. |
| A | --- | --- | 1.10 | --- | --- | 0.043 |
| A1 | 0.05 | --- | 0.15 | 0.002 | --- | 0.006 |
| A2 | 0.81 | 0.86 | 0.91 | 0.032 | 0.034 | 0.036 |
| c | 0.13 | --- | 0.23 | 0.005 | --- | 0.009 |
| b | 0.25 | --- | 0.40 | 0.17 | --- | 0.27 |
| D | 2.90 | 3.00 | 3.10 | 0.114 | 0.118 | 0.122 |
| E | 2.90 | 3.00 | 3.10 | 0.114 | 0.118 | 0.122 |
| HE | 4.90 BSC | | | 0.193 BSC | | |
| L | 0.445 | 0.55 | 0.648 | 0.0175 | 0.0217 | 0.0255 |
| θ1 | 0° | | 6° | 0° | | 6° |
| e | 0.50 BSC | | | 0.02 BSC | | |

## 12. REVISION HISTORY

| VERSION | DATE | PAGE | DESCRIPTION |
|---|---|---|---|
| 0.1 | 12/18/2008 | N.A. | New create |
| 0.2 | 5/26/2009 | | First released. |
| 0.5 | 07/21/2010 | 2, 41 | Update the key specification and add the top marking specification |
| 0.51 | 07/28/2010 | All | Modify some descriptions |
| 0.6 | 09/15/2010 | All | Modify some descriptions<br><br>Update the ordering information |
| 1.0 | 08/15/2012 | All | All versions before 1.0 are preliminary versions |

## Important Notice

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**Insecure usage includes, but is not limited to: equipment for surgical implementation, atomic energy control instruments, airplane or spaceship instruments, the control or operation of dynamic, brake or safety systems designed for vehicular use, traffic signal instruments, all types of safety devices, and other applications intended to support or sustain life.**

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